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UNITED STATES DISTRICT COURT
CENTRAL DISTRICT OF CALIFORNIA

KEITH ANDREWS, an individual, TIFFANI ANDREWS, an individual, BACIU FAMILY LLC, a California limited liability company, ROBERT BOYDSTON, an individual, CAPTAIN JACK'S SANTA BARBARA TOURS, LLC, a California limited liability company, MORGAN CASTAGNOLA, an individual, THE EAGLE FLEET, LLC, a California limited liability company, ZACHARY FRAZIER, an individual, MIKE GANDALL, an individual, ALEXANDRA B. GEREMIA, as Trustee for the Alexandra Geremia Family Trust dated 8/5/1998, JIM GUELKER, an individual, JACQUES HABRA, an individual, ISURF, LLC, a California

Case No. 2:15-cv-04113-PSG-JEM

[Consol. with Case Nos. 2:15-CV-04573 PSG (JEMx), 2:15-CV-4759 PSG (JEMx), 2:15-CV-4989 PSG (JEMx), 2:15-CV-05118 PSG (JEMx), 2:15-CV-07051- PSG (JEMx)]

EXPERT REPORT OF HUNTER S. LENIHAN, Ph.D. **[CORRECTED]**

July 6, 2019

limited liability company, MARK KIRKHART, an individual, MARY KIRKHART, an individual, RICHARD LILYGREN, an individual, HWA HONG MUH, an individual, OCEAN ANGEL IV, LLC, a California limited liability company, PACIFIC RIM FISHERIES, INC., a California corporation, SARAH RATHBONE, an individual, COMMUNITY SEAFOOD LLC, a California limited liability company, SANTA BARBARA UNI, INC., a California corporation, SOUTHERN CAL SEAFOOD, INC., a California corporation, TRACTIDE MARINE CORP., a California corporation, WEI INTERNATIONAL TRADING INC., a California corporation and STEPHEN WILSON, an individual, individually and on behalf of others similarly situated,

Plaintiffs,

v.

PLAINS ALL AMERICAN PIPELINE, L.P., a Delaware limited partnership, PLAINS PIPELINE, L.P., a Texas limited partnership, and JOHN DOES 1 through 10,

Defendants.

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I. INTRODUCTION

1. I am a Professor of Applied Marine and Fisheries Ecology at the Bren School of Environmental and Science Management at the University of California, Santa Barbara ("UCSB"). I have had that job since 2010. Before that, I worked at the Bren School as an Assistant Professor from 2002-2006, and an Associate Professor from 2006-2009. Before my time at UCSB, I worked as a Fisheries Biologist in the West Coast Groundfish Management Program at the NOAA-National Marine Fisheries Service's Northwest Fisheries Science Center in Newport, Oregon. From 2003 to 2011, I was director of CALobster, a collaborative fisheries research program that worked with the Santa Barbara Channel spiny lobster and nearshore live fish fisheries. In 2015, I founded the Sustainable Aquaculture Research Center, which I direct with the goal of integrating aquaculture into a functioning and productive California seascape. My Center conducts research designed to better understand the ecological implications and impacts of aquaculture in marine ecosystems, the industrial lifecycle of aquaculture operations, and the capacity for aquaculture to produce food for humans, and conserve and enhance marine organisms and habitats. In the Santa Barbara region, we have focused our work mainly on the ecosystem impacts and benefits produced by the offshore mussel farm near Hope Ranch.

2. I have a Ph.D. in Marine Science from the University of North Carolina, Chapel Hill; a M.S. in Marine Science from the Moss Landing Marine Laboratories, through San Jose State University; and a B.S. in Conservation of Natural Resources from the University of California, Berkeley. My complete curriculum vitae, which details my extensive publishing, research, and teaching history, including a list of all my publications from the last 29 years, is attached to this declaration at Exhibit A. The list of publications includes the reporting of science about the impacts of oil spills and other pollutants on marine organisms; the influence of fishing on marine habitats and organisms; marine habitat restoration; the influence of marine reserves on populations of lobsters and grass rockfish, and the distribution of fishing effort for lobsters;

collaborative fisheries management; and the use of marine reserves and other spatial and quantitative tools in fisheries management. I oversaw the Ph.D. dissertations of Carla Guenther, Ph.D., who reported the influence of marine reserves on lobster fishing revenue as impacted by the marine reserves, and Heather Coleman who reported on the ecological effects of natural oil seeps. I currently have Ph.D. students conducting research on the Santa Barbara Channel rock crab and spiny lobster fisheries (Sean Fitzgerald) and aquaculture industry (Jose Zenteno). I have not provided expert testimony in any other case in the last four years.

3. The attorneys for the plaintiffs in this case retained me to provide my opinion regarding the likely effects on commercial fisheries from the May 19, 2015 oil spill from the Plains All American Pipeline on the Gaviota Coast. To form my opinions, I relied on my research and experience as a marine scientist; as well as my personal knowledge of the Gaviota Coast; the Santa Barbara Channel local trap or fixed-gear fisheries for lobster, grass rockfish, rock crab, and Kelletia snails, as well as the groundfish and diverse pelagic fisheries, and commercial fishing generally in the Southern and Central California coast.

4. I am being compensated at a rate of $300/hour for my work on this matter. In this Expert Report, I am providing the Court four opinions, each of which I hold on a more likely than not basis to a reasonable degree of scientific certainty. Each of these opinions are discussed in more detail below. In forming those opinions, I considered the facts or data cited or referenced in this report and in Exhibit E, as well as my prior declarations and deposition testimony in this matter. I reserve the right to amend this report to account for additional information. My opinions are:

a. The general effects of oil on marine ecosystems, like that which occurred on May 19, 2015 near Refugio State Beach (hereinafter "Refugio Oil Spill"), include both acute short-term and chronic long-term negative impacts on a wide variety of marine species, including those that are caught by the commercial fishing industry in the Santa Barbara Channel and southern California regions (Section II);

b. The general effects of fishery closures on fishing fleets in the Santa Barbara Channel ecosystem, especially in terms of the economic and social implications and impacts of establishing no-take zones (Section III);

c. The direct negative ecological effects of the Refugio Oil Spill on commercial fishery species (Section IV);

d. The probable future negative and indirect ecological effects of the Refugio Oil Spill on commercial fishery species (Section V).

II. GENERAL EFFECTS OF OIL ON MARINE ECOSYSTEMS

5. Scientific literature establishes that polycyclic aromatic hydrocarbons (PAHs) in crude oil, when released into the marine environment, cause acute short-term as well as long-term negative effects to marine habitats and the species that inhabit them.[1] Those effects include, but are not limited to: (A) the rapid dispersion of oil in surface and subsurface waters; (B) slow rate of oil degradation in subsurface sediments; (C) social disruption and decreased health in sea birds and mammals; (D) embryotoxicity, genotoxicity, developmental deformities, growth suppression, increased mortality, reduced immune system function, increased risk of disease and parasites, and reproductive issues in fish and invertebrates exposed to oil as embryos, larvae, juveniles, and adults; (E) increased mortality of macroalgal and shellfish-engineered biogenic habitats upon which many marine fish and invertebrates depend; and (F) potential for "cascades of delayed, indirect impacts" among fish and invertebrate populations long after the oil spill.[2] The emergence of new scientific studies and publications since the Deepwater Horizon Spill in 2010 confirm that even extremely low levels crude oil-derived PAHs [e.g., <50 part per billion (ppb) total PAHs in seawater] can cause

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[1] *See, e.g.*, Charles H. Peterson et al., *Long Term Ecosystem Response to Exxon Valdez Oil Spill*, 302 Sci. 2082 (2003).

[2] Jeffrey W. Short, *Advances in Understanding the Fate and Effects of Oil from Accidental Spills in the United States Beginning with the Exxon Valdez*, 73 Arch. Environ. Contam. Toxicol. 5 (2017).

biological injury to cells, organelles within cells, or molecular bio-chemical processes in wide variety marine organisms.[3]

6. Oil spills immediately and negatively impact marine environments and species by causing injuries to tissues and biochemical processes that lead to acute animal and plant mortality, as well as sub-lethal injuries that lead to abnormal embryonic development, reduced growth, and reproductive problems, all of which can lead to the reduction of population abundance and altered population structure (e.g., size and age structure). For example, researchers studying the legacy of the 1978 Amoco Cadiz oil spill off the coast of France found high initial mortality rates as well as delayed effects in mortality, growth, and recruitment (arrival of new individuals) in populations of crustaceans, bivalves (oysters, mussels, clams), and, in particular, sea urchins.[4] According to the authors of that study, "[s]pecies of clams and fishes have life expectancies of 5-10 years, and one would expect as much as 30 years or 3-6 generations for a complete recovery of a stable age distribution" after an oil spill event.[5] Similarly, a study of the 2002 Prestige oil spill on the Galician coast in Spain shows that oil spills cause immediate species loss, particularly among sensitive crustaceans (crabs, lobsters, and shrimp, as well as amphipod species).[6] That study found that "the most affected beaches lost up to 66.7% of the total species richness after the oil spill."[7]

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[3] Mace G. Barron, *Ecological impacts of the Deepwater Horizon Oil Spill: implications for immunotoxicity*, 40 Toxic. Pathol. 315 (2012). Andrew Whitehead et al., *Genomic and physiological footprint of the Deepwater Horizon oil spill on resident marsh fishes*, 50 Proc. Nat'l Acad. Sci. 20298 (2012). John P. Incardona et al., *Exxon Valdez to Deepwater Horizon: Comparable toxicity of both crude oils to fish early life stages*, 142 Aquat. Tox. (2013). John P. Incardona et al., *Deepwater Horizon crude oil impacts the developing hearts of large predatory pelagic fish*, E1510 Proc. Nat'l Acad. Sci. (2014). Kathryn A. O'Shaughnessy et al., *Toxicity of weathered Deepwater Horizon oil to bay anchovy (Anchoa mitchilli) embryos*, 148 Ecotox. Environ. Safety 473 (2018).

[4] Gerard Conan, *The Long-Term Effects of the Amoco Cadiz Oil Spill*, 297 Phil. Trans. of the R. Soc. Lond. B. 323 (1982).

[5] *Id.*

[6] R. de la Huz, *Biological Impacts of Oil Pollution and Cleaning in the Intertidal Zone of Exposed Sandy Beaches: Preliminary Study of the ''Prestige'' Oil Spill*, 65 Estuar, Coast. Shelf Sci. 19 (2005).

[7] *Id.*

7. In the mid-1990's, I supported Dr. Charles Peterson, who was my Ph.D. advisor at the time, in his study of the biological impacts of the Exxon Valdez oil spill on Prince William Sound. In addition to that work, I conducted research on the effects of hydrocarbons and other pollutants on benthic marine communities in Antarctica.[8] PAHs are hydrocarbons that are abundant in oil that has been in the ocean and/or has reached the shore of the ocean.[9] Research has shown that PAHs are not only harmful to human beings in high enough concentrations, but also cause growth and developmental defects in fish if they are exposed to PAHs as embryos.[10] Degraded oil has been shown to concentrate highly toxic PAHs, which means that oil traveling away from the source does not necessarily decline in toxicity.[11] Other forms of hydrocarbons in crude oil, including alkanes, many-ringed aromatic hydrocarbons, and aliphatic hydrocarbons, which are generally less toxic than 2-4 ringed PAHs, can still cause mortality and sub-lethal impact through toxicity[12] and the degradation of habitat.[13]

8. Many of the aforementioned impacts of crude oil on marine environments were seen in the aftermath of the 1989 Exxon Valdez disaster in Prince William Sound. That spill spawned extensive research regarding the ecological effects of oil spills in the marine environment. For example, researchers recently linked the collapse of the herring

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[8] Hunter S. Lenihan & John S. Oliver, *Anthropogenic and Natural Disturbances to Marine Benthic Communities in Antarctica*, 5 Ecol. Appl. 311 (1995).

[9] U. S. Environmental Protection Agency, *Polycyclic Aromatic Hydrocarbons on the Gulf Coastline* (Feb. 20, 2016).

[10] J.W. Short., *supra* note 2.

[11] A.J. Esbaugh et al., *The effects of weathering and chemical dispersion on Deepwater Horizon crude oil toxicity to mahi-mahi (Coryphaena hippurus) early life stages*, 543 Sci. of the Total Env't 644 (2016).

[12] Peter E. Benville Jr. & Sid Korn, *The Acute Toxicity of Six Monocyclic Aromatic Crude Oil Components to Striped Bass (Morones saxatius) and Bay Shrimp (Cragon fransicorum)*, 63 Cal. Dep't of Fish and Game 204 (1977).

[13] Thomas A. Dean & Stephen C. Jewett, *Habitat-specific recovery of shallow subtidal communities following the Exxon Valdez oil spill*, 11 Ecological Applications 1456 (2001); Thomas H. Suchanek, *Oil Impacts on Marine Invertebrate Populations and Communities* 33 American Zoologist 520 (1993).

fishery in Prince William Sound several years after the Exxon Valdez disaster to the oil released in that spill.[14] That study confirmed that even very low levels of exposure to crude oil (i.e., 0.23 parts per billion total PAHs in seawater) of herring larvae can lead to changes in fish heart structure that reduce individual fitness for years to come.[15] In addition to heart defects, researchers found that pink salmon that were exposed to PAHs at concentrations of 5 and 19 parts per billion (hereinafter "ppb") as embryos showed higher mortality rates in the two years following a spill than fish that were not exposed.[16] Herring and sea urchin embryos experience similarly adverse effects of crude oil exposure including inhibited skeletal growth, increased necrosis (cell death) and, in the case of herring, higher overall embryo mortality rate.[17]

9. Results of population modeling has shown that exposure of juvenile fish, specifically herring, to oil spilled by the M/T Antonio Gramsci in 1987 explained a decline in herring population abundance and fisheries catch in the Baltic Sea. The authors found that exposure at young ages of these rapidly growing fish reduced survival and thus recruitment, and also subsequent reproduction, thus leaving fewer individual adult fish to catch in the fishery.[18]

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[14] John P. Incardona, *Very Low Embryonic Crude Oil Exposures Cause Lasting Cardiac Defects in Salmon and Herring*, 5 Sci. Rep. 1 (2015).

[15] *Id.; see also* Stephen C. Jewett et al., *Exposure to Hydrocarbons 10 Years After the Exxon Valdez Oil Spill: Evidence from Cytochrome P4501A Expression and Biliary FACs in Nearshore Demersal Fishes*, 54 Marine Envtl. Res. 21 (2002) (concluding that fish that have been exposed to hydrocarbons may experience "deleterious physiological effects" long after the oil spill).

[16] Ron A. Heintz, *Delayed Effects on Growth and Marine Survival of Pink Salmon Oncorhynchus gorbuscha After Exposure to Crude Oil During Embryonic Development*, 208 Mar. Ecol. Prog. Ser. 205 (2000).

[17] John P. Incardona et al., *Unexpectedly High Mortality in Pacific Herring Embryos Exposed to the 2007 Cosco Busan Oil Spill in San Francisco Bay*, 109 Proc. of the Nat'l Acad. of Sci. E15 (2012); Inger-Britt Falk-Petersen, *Toxic Effects of Aqueous Extracts of Ekofisk Crude Oil, Crude Oil Fractions, and Commercial Oil Products on the Development of Sea Urchin Eggs*, 64 Sarsia 161 (1979). Jeannette W. Struhsaker et al. *Effects of benzene (a water-soluble component of crude oil) on eggs and larvae of Pacific herring and northern anchovy*. Pollution and Physiology of Marine Organisms. FJ Vernberg & WB Vernberg, eds (1974).

[18] Mika Rahikainen et al., *Impacts of eutrophication and oil spills on the Gulf of Finland*

10. These findings are consistent with research conducted on the ecological effects of Refugio Oil, in a laboratory study that demonstrated that concentrations of PAHs as low as 38.5 and 53.1 ppb inhibited the population growth of *Psuedo-nitzschia australis*, a common phytoplankton in the Santa Barbara Channel (SBC) ecosystem.[19] A PAH concentration as low as 35.1 ppb also reduced the growth rate of another common phytoplankton in the SBC ecosystem, the coccolithophore phytoplankton *Emiliana huxleyi*. One of the oils used in the experiment was the same oil that spilled during the Refugio Oil Spill. The phytoplankton species tested in the study provide a basal food source for the marine food webs that supports the 64 species of fish and invertebrates that are targeted in the commercial fisheries operating in southern California's marine coastal environment.

11. Examination of the Exxon Valdez oil spill and the Deepwater Horizon oil spill also indicates that oil spilled in the marine environment has a wide array of indirect negative impacts on many marine organisms due to ecological linkages.[20] Crude oil and its many constituents kills, injures, or contaminates the carcasses of smaller prey organisms, including phytoplankton, zooplankton, and plants, deposit and filter feeding invertebrates, or juvenile or adult fishes that are then eaten by large herbivorous, predators, or scavengers. If smaller prey are killed by oil and reduced in their population abundance, the result is to decrease the amount of food and nutrition available for their consumers, which in turn reduces the consumer's rates of growth, survival, and reproduction. This, in turn, leads to population declines in the consumers, like that seen in bird, mammal, fish, and invertebrate populations in Prince William Sound and the Gulf of Mexico after the major spills in these ecosystems.

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herring stock, 74 Can. J. Fish. Aquat. Sci. 1218 (2017).

[19] Tanika M. Ladd et al., *Exposure to oil from the 2015 Refugio spill alters the physiology of a common harmful algal bloom species, Pseudo-nitzschia australis, and the ubiquitous coccolithophore, Emiliania huxleyi*, 603 Mar. Ecol. Prog. Ser. 61 (2018).

[20] J.W. Short., *supra* note 2.

12. Other indirect impacts of spilled oil concern the degradation or destruction of benthic habitat, such as marine plants, macroalgae, biogenic reefs (e.g., made by oysters, mussels, and corals), rocky reefs, and soft-sediment bottoms, that provide shelter, refuge, food resources, or substrates for egg laying or nest building for many organisms.[21] Marine fauna can decline in abundance or perish due to declines in the quantity and quality of habitat that is impacted by oil.

13. The economic impact of an oil spill on the local fishing industry is the result of more than just damage to natural resources. For example, the authors of one report following the Deepwater Horizon disaster note that economic loss results from a "combination of initial mortality of fish species due to the oil spill as well as the continued economic unmarketability that can result when consumers believe marine products . . . are less desirable."[22] This "economic unmarketability" can translate into decreased demand for seafood in oil spill-affected areas, even months after the spill occurs. Similar effects were observed in the Refugio Oil Spill by several seafood buyers and distributors.[23] For example, six months after the Deepwater Horizon spill, 23% of consumers in a Louisiana poll had decreased their consumption of Gulf seafood and 70% were worried about safety of Gulf seafood.[24] Fishers and processors have testified that a similar pattern emerged in the Refugio Oil Spill.[25] Subsequent analysis showed substantial negative economic impacts of the Deepwater Horizon spill on fisheries revenues, profits, wages, and jobs, and forecasted continued negative economic impact for up to seven years after the spill. Similar short and long-term negative economic

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[21] Charles W. Martin and Erick M. Swenson, *Herbivory of oil-exposed submerged aquatic vegetation Ruppia maritima*, PLoS ONE 13(12): e0208463 (2018); C.H. Peterson, *supra* note 1; H.S. Lenihan and J.S. Oliver, *supra* note 7; Incardona et al., *supra* note 17.

[22] U. Rashid Sumaila et al., *Impact of the Deepwater Horizon Well Blowout on the Economics of U.S. Gulf Fisheries*, 69 Can. J. Fish. Aquat. Sci. 499 (2012).

[23] *See* Baez Dep., Aug. 5, 2016; Rathbone Dep., Aug. 19, 2016.

[24] Harold F. Upton, Cong. Research Serv., R41640, *The Deepwater Horizon Oil Spill and the Gulf of Mexico Fishing Industry* (2011).

[25] *See* Muh Dep., Aug. 2, 2016; Guglielmo Dep., Sept. 20, 2016.

impacts on marine fisheries caused by oil spills have been reported frequently in peer-reviewed scientific literature.[26] In sum, oil spills cause both acute and long-term harm to a wide variety of fisheries and the industries that rely on them.

III. GENERAL EFFECTS OF CLOSURES ON FISHERIES IN THE SANTA BARBARA CHANNEL ECOSYSTEM

14. As Principal Investigator on Fisheries Research projects that I directed as a Professor at UCSB's Bren School of Environmental Science & Management, and as a Project Investigator for the Santa Barbara Coastal Long-Term Ecological Research Program, administered through UCSB's Marine Science Institute, I have extensive personal knowledge of the regional commercial fishing industry. Through my research in and around the Santa Barbara Channel and Santa Barbara Harbor, I have gained first-hand knowledge about decision-making on commercial fishing vessels, the population dynamics of target organisms, and, more generally, fisheries management in the Santa Barbara area.[27] For example, I examined the impact of no-take marine reserves/marine protected areas (MPAs) on ecological responses, such as grass rockfish growth rates and

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[26] J. Goodlad, *Effects of the Braer oil spill on the Shetland seafood industry*, 186 Sci. of the Total Env't 127 (1996); W.H. Pearson et al., *Assessment of damages to commercial fisheries and marine environment of Fujairah, United Arab Emirates, resulting from the Seki oil spill of March 1994: a case study*, Yale Sch. of Forestry & Envtl. Stud. Bull. 103 (1998); T.H. Moller et al., *Fishing and harvesting bans in oil spill response*, 1999 Proc. of Int'l Oil Spill Conf. 693 (1999); M.C. García Negro et al., *Estimating the economic impact of the Prestige oil spill on the Death Coast (NW Spain) fisheries*. 33 Marine Policy 8 (2009); A. Punzón et al., *Closed area management taken after the 'Prestige' oil spill: effects on industrial fisheries*, 2 Marine Biodiversity Recs. e75 (2009); S.M. Cheong, *Fishing and tourism impacts in the aftermath of the Hebei-Spirit oil spill*. 28 J. of Coastal Res. 1648 (2012); S.E. Chang et al., *Consequences of oil spills: a review and framework for informing planning*, 19 Ecology and Soc., no. 2, 26. (2014).

[27] *See*, *e.g.*, Matthew C. Kay et al., *Cost of Vessel Insurance in Collaborative Fisheries Research: Strategies and Perspectives from a Program in California, USA*, 96 Cali. Fish and Game 129 (2010). *See also* Matthew C. Kay et al., *Collaborative Assessment of California Spiny Lobster Population and Fishery Responses to a Marine Reserve Network*, 22 Eco. App. 322 (2012); Matthew C. Kay et al., *Effects of marine reserves on California spiny lobster are robust and modified by fine-scale habitat features and distance from reserve borders*. Marine Ecology Progress Series 451 (2012). Wilson et al., *Small-Scale Spatial Variation in Population Dynamics and Fishermen Response in a Coastal Marine Fishery*, 7 PLoS ONE e52837 (2012). (analyzing lobster and rockfish fisheries near marine reserves)

spawning potential, as well as fishing behavior of and economic impacts to fishermen, including where they select to fish.[28] To build upon this knowledge base, I have reviewed additional research materials and documents provided to me that describe the fishing industry in the area impacted by the Refugio Oil Spill, including depositions of plaintiffs in this case.[29] My prior research and personal experience, together with my review of case documents and other materials demonstrate that the fishing industry is a significant economic sector in this region that relies on many fisheries affected by the Refugio Oil Spill.[30]

15. For example, in Santa Barbara, "between 1980 and 2013, the commercial fishing industry generated over $382.5 million across a range of species[.]"[31] There were about 1,900 commercial fishing vessels that landed catch at California ports in 2012. Altogether, roughly 592 of those vessels landed at ports in Santa Barbara, Los Angeles, and San Luis Obispo counties in 2012. The breakdown of number of these vessels by county is as follows: approximately 188 vessels in Santa Barbara, 206 vessels in Los Angeles, 187 vessels in Ventura, and 201 vessels in San Luis Obispo.[32] Region-wide, it

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[28] Wilson et al., *Integration of No-Take Marine Reserves in the Assessment of Data-Limited Fisheries*, 7 Conservation Letters 451 (2014); Guenther et al., *Differences in Lobster Fishing Effort Before and After MPA Establishment*, 59 App. Geog. 78 (2015). Guenther, C. *A Socio-Ecological Analysis of Marine Protected Areas and Commercial Lobster Fishing in the Santa Barbara Channel California* (Doctoral Dissertation). University of California, Santa Barbara (2010).

[29] *See* Baez Dep., Aug. 5, 2016; Castagnola Dep., July 27, 2016; Gandall Dep., July 14, 2016; Muh Dep., Aug. 2, 2016; D. Nguyen, July 26, 2016; T. Nguyen Dep, Sept. 20, 2016; Guglielmo Dep., Sept. 20, 2016; Rathbone Dep., Aug. 19, 2016; Zhuang Dep., Aug. 3, 2016; Tibbles Dep., Aug. 13, 2016; Andrews Dep., July 13, 2016 (describing fishing industry in the impacted area in this case).

[30] California Environmental Protection Agency, *Refugio Beach Oil Spill Incident Fisheries Closure Chemical Testing Results Summary* (2015); California Environmental Protection Agency, *Protocol for Seafood Risk Assessment to Support Fisheries Re-Opening Decisions for Aquatic Oil Spills in California* (2015); United States Coast Guard, *Emergency Response Sampling & Analysis Work Plan ICP Goleta* (2015).

[31] Commercial Fishermen of Santa Barbara, 2014 Commercial Fisheries Economic Impact Report 1 (Apr. 2015).

[32] University of California San Diego, California Sea Grant, "Statewide Commercial Fishery Activity," https://caseagrant.ucsd.edu/project/discover-california-commercial-fisheries/statewide-commercial-fishery-activity.

has been estimated that, in 2013, commercial fishermen landed more than 111 million pounds of seafood in the Santa Barbara Channel area, creating an ex-vessel value of nearly $50.5 million.[33] Altogether, the Point Conception and nearby Santa Barbara Channel areas "serve as spawning and rearing areas for approximately 64 species of commercial fish and shellfish throughout the year."[34]

16. My work with fisheries in the Santa Barbara Channel includes supervising and collaborating on Ph.D.-level studies of the impact of the no take marine reserves, established in 2003 at Santa Cruz, Santa Rosa, and San Miguel Islands, on spiny lobster populations and the spiny lobster fishery. These findings were reported in several peer-reviewed academic journals, Kay et al. (2012a, b) and Guenther et al. (2015), and a Ph.D. Dissertation (Guenther 2010). We found that when the CA State government established that these areas would be closed to all fishing, lobster fishermen responded to the loss of fishing ground, either by quitting the fishery (as 8% did), or moving to new fishing grounds. Moving to new fishing grounds entails greater fishing effort in terms of fuel use and "pulling" (i.e., sampling) traps, in order to test whether new grounds are good habitats to fish. A similar effect was reported by fishers impacted by the Refugio Oil Spill.[35]

17. In the Guenther 2010 and 2015 studies, it was determined that fishers experienced a significant decline in lobster catch due to the loss of fishing grounds, and because they were unfamiliar with new fishing grounds, despite an overall increase in the lobster population, they also experienced declines in total revenue, due to the time spent sampling traps and related travel costs, even though prices increased significantly in the

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[33] University of California Santa Barbara, California Sea Grant, "Santa Barbara Channel," https://caseagrant.ucsd.edu/project/discover-california-commercial-fisheries/regions/santa-barbara-channel.

[34] County of Santa Barbara Planning and Development Energy Division, "Commercial Fishing," http://www.sbcountyplanning.org/energy/mitigation/commercialFishing.asp.

[35] *See e.g.*, Tibbles Dep., Aug. 13, 2016; Andrews Dep., July 13, 2016 (describing the move to new fishing grounds in this case).

period after the no take areas were established. *See* Guenther (2010) and Guenther et al. (2015). This scenario provides a salient example of the substantial short-term loss in fishing revenue associated with trap fishermen that can result from being forced to move from well-known fishing grounds.[36]

18. The results of our research are also consistent with reports of fishers in the aftermath of the Refugio Oil Spill.[37] The plaintiffs in this case fish for a variety of species in the Santa Barbara Channel and along the Central and Southern Coast, including sea cucumbers, shrimp (prawn), halibut, kelletia snails, crab, black cod (sablefish), lobster, and squid.[38] Other plaintiffs process and sell those species and many others, like sea urchin, also called uni.[39]

19. The most immediate impact of the Refugio Oil Spill to commercial fishers like the Plaintiffs was, of course, the closure for over one month of the 138 square-mile area from Canada de Alegeria at the western edge to Coal Oil Point to any commercial fishing due to human health concerns associated with the spill.[40] As shown in my research on the establishment of no-take reserves, the closure of known fishing grounds, or loss of those grounds due to habitat degradation, results in extensive costs to fishers. And as detailed in this report, the end of that temporary closure following the spill did not end the impacts of the spill.

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[36] Mike Gandall reported a similar impact on his lobster fishing behavior as a result of the Refugio Oil Spill. Gandall Dep., July 14, 2016

[37] *See* Baez Dep., Aug. 5, 2016; Castagnola Dep., July 27, 2016; Gandall Dep., July 14, 2016; Muh Dep., Aug. 2, 2016; D. Nguyen, July 26, 2016; T. Nguyen Dep, Sept. 20, 2016; Guglielmo Dep., Sept. 20, 2016; Tibbles Dep., Aug. 13, 2016; Andrews Dep., July 13, 2016.

[38] Plaintiffs' Corrected Consolidated Second Amended Complaint ("Complaint") at ¶¶ 101, 127, 131, 142, 150, 201.

[39] Complaint at ¶¶ 193, 206, 212, 216, 223, 236.

[40] See California Dept. of Fish and Wildlife, Refugio Oil Spill Response Evaluation Report: Summary and Recommendations from the Office of Spill Prevention and Response 36-38 (May 2016) (describing closure).

IV. DIRECT NEGATIVE EFFECTS OF THE REFUGIO OIL SPILL

20. On May 22, three days after the Plains oil spill, three UCSB divers, working for my colleague Dr. Miller, conducted a subtidal survey on the eastern side of Refugio cove at 11:30 a.m. at the approximate location of 34.461 N; -120.066 W, and at a depth of 25-30 feet over patchy rock reef and sand. Dr. Miller reported to me upon request that his team immediately noticed “clumps” of oil varying in size from 1mm to 15+cm.

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21. The largest concentrations of oil clumps were found in natural depressions on the reef and were generally mixed in with bits of algae and other natural debris. Dr. Miller’s team observed this phenomenon—crude oil settling on depressions in the reef and—over the entire area that they dove in. Similar clumps were found on area beaches:

22. Dr. Miller's team informed me that, later that same day, at approximately 1:15 pm, they conducted another subtidal survey on the western side of Refugio cove at the approximate location of 34.4599 N, -120.0721 W at a depth of 20-30 feet over patchy rock reef and sand. They reported that visibility at this site was much less, approximately 1 to 2 meters. Like the first location, however, Dr. Miller's team saw a similar distribution of oil on the bottom but with higher concentrations and large amounts of sticky, raw, and uncongealed oil blending in with surf-grass, red algae, and anything else it could foul. Photos of that phenomenon are attached as Exhibit B. At this site, Dr. Miller's team said visible oil covered their gear and camera after the dive.

23. Both of the reefs that Dr. Miller's team surveyed have a rich and highly species diverse algae, invertebrate, and fish community. Dr. Miller reported to me that he and his team observed an abnormally large concentration of freshly dead kelp crabs, purple sea urchins, and spiny lobsters. The seafloor at both sites is a critically important habitat for spiny lobster, grass rockfish, kelp bass, sea urchins, as well as the species upon which these species feed. It is also a nursery habitat for the early life stages of groundfish species, including sand dab and lingcod. The algae that Dr. Miller's team observed the oil intermixing with is a critical natural feature for lobster and crab because it provides them substrate that provides refuge from their predators, and those crustaceans settle as larvae in nearshore shallow water algal and plant beds, especially surf-grass. Squid also lay their eggs on benthic algal mats and patches of surf-grass. Grass rockfish live in and around surf-grass and shallow subtidal algal beds. The oil in these reefs will have impacted these species in varying ways, from causing physical harm to causing them to move to other areas in the ocean. Oil that contaminated sediments in and around algal mats and the rocky reefs will have negatively influenced rock crabs, specifically yellow rock crab, and flat fish, including sand dabs and halibut that inhabit mostly sandy or otherwise soft-sediment bottoms.

24. Sampling of the water column and marine benthic sediment for PAHs and other Petroleum Hydrocarbon constituents was conducted by the California Environmental Protection Agency near the offshore mussel farm located in Fishing block 653 during the period May 27 to July 2, specifically 8-52 days after the Refugio Oil Spill. Concentrations of total PAHs in the water column were as high as 0.45 ppb in surface waters, 0.61 ppb in midwater, 3.14 ppb in bottom water, and 300 ppb in sediments[41]. This mussel farm is located more than 10 miles from the spill and sampling was conducted at

[41] Center for Toxicology and Environmental Health, LLC, *Refugio Incident Water Column and Sediment, Sampling Report, Mussel Farm, Goleta, California, May 27, 2015- July 2, 2015,* CETH Project Number 107315.

least eight days after the spill. The Total BaPE measured in mussel tissues sampled from May 24, 2015- June 18, 2015 from Fishing blocks 654-656 were as high as 264.3 ppb[42] Total BaPE is the concentration of benzo(a)pyrene equivalents measured in the tissue of an organism exposed to PAHs, and is considered the most valid measure of the carcinogenic potency of a complex mixture of PAHs. Total BaPE is only a fraction of total PAHs, so the total PAHs had to be higher than 264.3 ppb in the mussel tissues, indicating the mussels were probably exposed to very high concentrations of oil. These data imply that organisms nearer to the spill than the mussel farm were also exposed to very high concentrations of PAHs.

25. Models of oil dispersion from the Refugio Oil Spill generated by Professor Igor Mezic, based on the positive matches for Plains oil that were identified through the SCAT oil sampling program, produce estimates of total PAH concentrations above zero and up to 180 ppb in the top cubic meter of water across 165 of 244 fishing blocks. That model was based on an estimate of 10,750 barrels of oil spilled that reached the seawater. A "lower bound" estimate of 8000 barrels produced estimates of total PAHs concentrations also of up to 180 ppb in the top cubic meter of water across the same range of fishing blocks. Professor Mezic's data reports concentrations of oil in units of grams of oil per liter of seawater. I used a conversion factor provided by Dr. Arturo Keller to convert the grams of oil per liter of seawater in order to obtain the equivalent concentration of total PAHs in the oil from Mezic's data.[43]

26. Based on my research and review of research of other ecological events and studies, I used a conservative threshold of 50 ppb total PAHs as the concentration that is

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[42] CEPA, *Refugio Beach*, *supra* note 30.

[43] Dr. Keller and his research team assisted in developing the conversion factor, based on a synthesis of scientific literature, and considering the type of oil released by Plains during the Refugio Oil Spill. Dr. Keller subsequently informed me that there is a maximum concentration of total PAHs in water. The maximum numbers and average numbers in paragraphs 25 and 27 have been adjusted accordingly, using Dr. Boehm's estimated maximum of 180 ppb of total PAHs. None of these adjustments impact my opinions regarding the toxicity of the Refugio Oil Spill on fisheries and marine species, or the number of toxic fishing blocks.

sufficiently toxic to harm all fishery and other marine species acutely enough to reduce their demographic performance, specifically their growth, survival, and/or reproduction. Reduced demographic performance leads necessarily to reduced population abundance and lower catch in a fishery. The 50 ppb is based on the results of studies from the scientific literature, including: (1) Incardona et al. (2015)[44] found that embryonic herring and pink salmon exposed to concentrations of only 0.23 ppb and 45 ppb of PAHs, respectively, significantly reduced the swimming speed, cardiac function, and cardiac structure of juveniles that developed from the exposed embryos; (2) Ladd et al. (2018)[45] found that concentrations of 50 ppb PAHs in Refugio spilled oil significantly reduced the population growth rate of phytoplankton, specifically *Emiliana huxleyi,* which is one of the species that provides a primary energy source for the food web that produces the 64 species targeted in the region's fisheries; and (3) O'Shaughnessy et al. (2018)[46] reported that a range of only 1.5-4.3 ppb PAHs was toxic to anchovy embryos, killing at least 50% of them in 48 hour tests; (4) Esbaugh et al. (2016) found that 8.8 ppb PAHs killed 50% of mahi-mahi embryos[47]; (5) Incardona et al. (2014) showed that 3.4-13.8 ppb PAHs caused gross morphological defects in bluefin tuna, yellowfin tuna, and amberjack larvae, as shown in photo below[48]; and (6) Jeong and Cho (2005) reported that exposure to 50 ppb PAHs substantially reduced the number of hemocyte ("blood") cells in Pacific oysters.[49] These results are summarized in the table below.

[44] Incardona et al., *supra* note 14.
[45] Ladd et al., *supra* note 19.
[46] O'Shaughnessy et al., *supra* note *3*.
[47] Esbaugh et al, *supra* note 11.
[48] Incardona et al. (2014), *supra* note 3.
[49] Woo-Geon Jeong and Sang-Man Cho, *Effects of polynuclear aromatic hydrocarbons on hemocyte characteristics of the Pacific oyster, Crassostrea gigas*. 24 Journal of Shellfish Research, 451 (2005).

Case study:	Related Oil Spill:	Organism:	Biological response*:	Toxic PAH level:	Toxic at ≤50 ppb:
1. Ladd et al. (2018)	Refugio 2015	Coccolithophore (*Emiliana huxleyi*) – population	Population growth rate reduced	35.1 ppb	Yes
2. Ladd et al. (2018)	Refugio 2015	Dinoflagellate (*Pseudo- nitzschia australis*) – population	Population growth rate completely inhibited	38.5 ppb	Yes
3. Incardona et al. (2015)	Exxon Valdez 1989	Pacific herring – embyro	Cardiac function (critical swimming speed in cm/sec)	0.23 ppb	Yes
4. Incardona et al. (2015)	Exxon Valdez 1989	Pink salmon – embryo	Cardiac function (critical swimming speed in cm/sec)	45 ppb	Yes
5. O'Shaughnessy et al. (2018)	Deepwater Horizon 2010	Bay anchovy – embryo	Mortality (LC_{50})	4.3 ppb	Yes
6. Esbaugh et al. (2016)	Deepwater Horizon 2010	Mahi-mahi – embryo	Mortality (LC_{50})	8.8 ppb	Yes
7. Incardona et al. (2014)	Deepwater Horizon 2010	Bluefin tuna, Yellowfin tuna, Amberjack– embryos	Gross morphological defects (see photo below)	3.4-13.8 ppb	Yes
8. Jeong and Cho. (2005)	No spill; Laboratory study	Pacific oyster	Reduction in the number hemocytes ("blood" cells)	50 ppb	Yes

Table 1. Results of PAH toxicity tests with marine phytoplankton (1-2), fish (3-7), and an invertebrate (8) from case studies related to oil spills in the marine environment.** Statistically significant biological response at P≤0.05. LC_{50} = Concentration that caused 50% mortality of population in test. ppb = parts per billion (µg PAHs/L seawater)

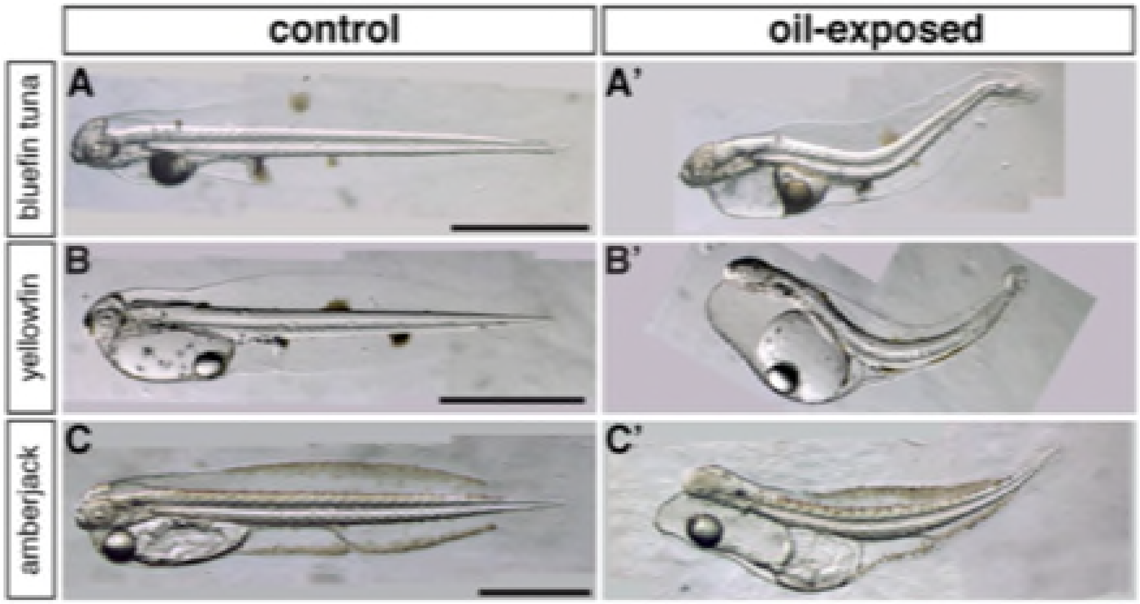

Fig. 2. Gross morphology of hatching stage larvae exposed to MC252 HEWAFs oil during embryonic development. Embryos were exposed from shortly after fertilization to 12–16 h after hatching. Unexposed controls incubated in clean water are shown in *A–C*, and oil-exposed (highest-dose tested) in *A′–C′*. Representative examples are shown for (*A*, *A′*) bluefin tuna exposed to artificially weathered source oil (1 mg/L oil, 8.5 μg/L ΣPAH), (*B*, *B′*) yellowfin tuna exposed to slick A (2 mg/L oil, 3.4 μg/L ΣPAH), (*C*, *C′*) amberjack exposed to artificially weathered source oil (1 mg/L oil, 13.8 μg/L ΣPAH). (Scale bars, 1 mm.)

27. Of the 244 total Fishing Blocks used in Dr. Mezic's analyses, 165 of them contained Line 901 oil at some point during the nearly three-month period over which Dr. Mezic ran his model. Using his estimate of 10,750 barrels of oil that entered the ocean, the result was that 75 fishing blocks had total PAH concentrations that were equal to or exceeded 50 ppb PAHs (for the period May 19-August 17), and therefore should be considered toxic to fishery species. The average maximum total PAHs in those 75 toxic blocks was 144.80 ppb, with a minimum single value of 51 ppb and maximum single value of 180 ppb total PAHs. The average PAH concentration across all 165 oiled blocks was 24.79 ppb. Using the alternative lower estimate of 8000 barrels, 67 blocks had concentration of total PAHs ≥50 ppb and should be considered toxic. The average

maximum of those 67 toxic blocks was 142.49 ppb total PAHs, with the maximum single value of 180.0 ppb and a minimum single value at 51 ppb. The average total PAH concentration across all blocks with oil was 20.18 ppb.

28. The 75 toxic blocks (those at ≥50 ppb) in the 10,750 barrel estimate were #651-656, 664-671, 679-689, 701-710, 718-728, 739-748, 759-768, 805-811, and 827-828 (See Exhibit C). The 67 toxic blocks (those at ≥50 ppb) in the 8,000 barrel estimate were #651-656, 664-670, 679-689, 701-710, 718-727, 739-748, 759-766, and 806-810. Under either scenario, the toxic blocks encompass most of the fishing blocks located from just west of Refugio Beach to Encinitas, and from the coastline to about the west edge of the Channel Islands located offshore. These toxic blocks include all but one of the "seafood" fishing blocks identified in the class definition. When using the 8000 barrel estimate, only two blocks, #657 and 671, that are included in the definition of the certified "seafood" class, were not toxic. In both estimates, blocks 684-689 of the "groundfish" class blocks were toxic.

29. I provided the results of my toxic block analysis to Dr. Peter Rupert. I understand that Dr. Rupert used that information to conduct his Difference in Difference Statistical Analysis, and that those findings confirm my conclusions that those blocks identified as "toxic" also experienced lower levels of catch for a number of species over a number of years.

30. Some species are of particular note because they illustrate the impact and damage from exposure to toxic levels of oil, to both current and future generations of fish. Northern anchovy and Pacific sardine lay eggs and develop from fish larvae into juveniles and adults, all in the ocean's surface water, and within a 2-year period. Oil was dispersed in this ecosystem during periods when the fish spawn, feed, and grow, such that these species were exposed to toxic PAHs oil from the spill. In addition, both species feed on plankton and other particles in surface waters, so juvenile and adult anchovies and sardines were exposed to probable ingestion of Refugio oil. Prior research indicates that oil is toxic and causes embryonic developmental problems and elevated mortalities to

juvenile fish in the families of Clupeidae (sardines, herring) and Engraulidae (anchovies) when exposed to concentrations of crude oil and its associated PAHs, like that estimated from the Refugio Oil Spill.[50] Market squid are one of the most valuable fishery species targeted by the area fishing fleets, such as in blocks #651-656, 664-671[51], and 681-683, which had PAH concentrations of ≥50 ppb.

31. Even very low concentrations of oil spilled into the marine environment is toxic and causes injury, reduced growth, and elevated mortality to squid or their close molluscan relatives, such as octopus.[52] The market squid *Loligo opalescens* lives only about one year and so the exposure to Refugio oil, especially at the juvenile life stage, undoubtedly caused mass mortality in squid populations. Furthermore, larvae of molluscan species and other organisms already physiologically stressed by high temperatures and low food conditions associated with El Nino-ENSO events in 2014-2016 were especially sensitive to toxic pollutants, including PAHs and other toxic chemicals present in Refugio spilled oil.[53]

32. Two other fisheries important to area fishing ports target rock crab and red sea urchins, and do so consistently in fishing blocks #651-656 and 681-683. These species are long-lived (>10 yrs.), grow relatively slowly, and live on the sea floor, mainly associated with rocky reef habitat but also soft-sediment bottom habitats. Having a relatively sedentary juvenile and adult existence is a life history characteristic shared by rock crab, sea urchins, and spiny lobster places these organisms at risk to oil spills. The spilled oil not only spread rapidly in surface waters but also sank and deposited in the

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[50] Tara A. Duffy, et al. *Responses of bay anchovy (Anchoa mitchilli) larvae under lethal and sublethal scenarios of crude oil exposure*, 134 Excotox. Environ. Safety 264 (2016); Incardona et al. (2012), *supra* note 17.

[51] In the 8,000 barrel estimate block 671's level of PAH is 46.3 ppb

[52] Sara M. Long et al, *Acute toxicity of crude and dispersed oil to Octopus pallidus (Hoyle, 1885) hatchlings*, 36 Water Research 2769 (2002). Bruce M. Hendry et al., *The actions of some narcotic aromatic hydrocarbons on the ionic currents of the squid giant axon*. 224 Proc. Royal Soc. London. Ser. B. Biol. Sci. 389 (1985).

[53] Andrew Whitehead, *Interactions between oil-spill pollutants and natural stressors can compound ecotoxicological effects*, 53 Integr. Comp. Bio. 635 (2013).

benthic, subtidal environment. Oil deposited on seafloor exposes benthic, sedentary organism, like rock crabs, sea urchins, and spiny lobster to PAHs and other chemicals that have been shown to be toxic, and cause either acute toxicity in the form of mortality, or chronic toxicity, in the form of reduced growth and reproduction, increased morbidity, and reduced immune-function leading to enhanced disease impacts and parasitism. This is especially the case for crustaceans, including crabs, as well as sea urchins, as they are very sensitive to many toxicants. Exposure to oil that sank and deposited on the seafloor is expected to impact the number of rock crabs and red sea urchins harvested in the affected area.

33. Larval fish and pelagic juvenile fish are highly susceptible to PAH toxicity as stated above. These stages of fish are found annually in high concentrations within the Santa Barbara Channel, especially during the months of May and June, when many species spawn, and when the young become heavily concentrated in space due to the formation of coastal eddy circulation patterns that move slowly through across the Santa Barbara Channel ecosystem from east to west.[54] The coastal eddies are a consistent physical feature during the spring season that transports, “captures”, and concentrates fish thus increasing their density relative to non-eddy conditions. It is scientifically reasonable to conclude that pelagic juvenile fish were concentrated in the eddies in May and June of 2015 in the region of blocks 666-671, which had levels of PAHs that are toxic to larval and juvenile fish (i.e., had concentrations greater than 0.23 ppb, as well as a maximum of ≥50 ppb). Thus, the eddy circulation would be expected to enhance the exposure of young fish to toxic PAH concentrations, thus leading to a decline in their catch.

V. LONGTERM AND INDIRECT NEGATIVE EFFECTS OF THE REFUGIO OIL SPILL

34. Scientists that studied the Exxon Valdez oil spill (“EVOS”) of 1989 came to the consensus that crude oil and its many toxic constituents, especially PAHs, causes

[54] Mary M. Nishimoto and Libe Washburn, *Patterns of eddy circulation and abundance of pelagic juvenile fish in the Santa Barbara Channel, CA, USA*, 241 Mar. Ecol. Prog. Ser. 183 (2002).

unexpected long-term biological effects.[55] A large suite of peer-reviewed publications have documented negative impacts of EVOS crude oil to marine organisms, some almost 25 years after the spill, and changed the prevailing paradigm of oil spills, focusing much attention on the geochemical and biological processes that lead to long term declines in marine species.[56]

35. A major finding of EVOS research was that oil can persist in sediments, releasing PAHs very slowly and exposing animals to toxic concentrations for decades.[57] Before EVOS, we generally underestimated the habitat damage resulting from oil contamination, and the subsequent impacts it can have on biota. Nearshore substrates oiled by spills may become persistent sources of PAHs, which are released from oil films and droplets. The eggs from demersally-spawning species, including herring and squid, and the benthic juveniles of many fish and invertebrates, can accumulate dissolved PAHs released from oiled substrates, even when the oil is heavily weathered. PAHs accumulated by embryos from crude oil-laden water can lead to adverse sequelae appearing at random over the lifespan of an exposed cohort (age class), probably as a result of damage during early embryogenesis.[58] This toxicity pathway also led to long-term declines in herring populations after the 2007 Cosco Busan oil spill in San Francisco Bay, an accident much smaller in volume than EVOS. Long-term declines in herring were also observed after the 1987 M/T Antonio Gramsci oil spill in the Baltic Sea.[59] The

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[55] C.H. Peterson et al., *supra* note 1; J.W. Short, *supra* note 2.

[56] Hailong Li and Michael C. Boufadel, *Long-term persistence of oil from the Exxon Valdez spill in two-layer beaches*, 3 Nature Geoscience 96 (2010). Marcia McNutt, Exxon Valdez: *25 years later*, 343 Science 1289 (2014). Jeffrey W. Short et al., *Long-term effects of crude oil from the Exxon Valdez*, 25 Energy Sources 509 (2003). Daniel H. Monson et al., *Long-term impacts of the Exxon Valdez oil spill on sea otters, assessed through age-dependent mortality patterns*, 97 Proc. of the Nat'l Acad. of Sci 6562 (2000).

[57] Li and Boufadel, *supra* note 56. Michael C. Boufadel et al., *Nutrient and oxygen concentrations within the sediments of an Alaskan beach polluted with the Exxon Valdez Oil Spill*, 44 Environ. Sci. Technol. 7418 (2010).

[58] J.W. Short, *supra* note 56.

[59] Incardona et al., *supra* note 17. Mika Rahikainen et al., *supra* note 18.

scientific consensus is that PAHs can be slow-acting, and toxic effects may not manifest until long after oil is spilled.

36. The potential for long-term declines in fishery species results from the Refugio Oil Spill are great. At a local scale, near the spill site in fishing Blocks 653-656, I expect a decline in the abundance of lobster catch over the next at least 1-5 years because (1) as Dr. Miller reported there was substantial morality in spiny lobster populations, especially young animals (EXHIBIT D), thereby reducing the number of lobsters that will grow to legal sizes to be caught and that will produce young; (2) oil contaminated the benthic macroalgae in the shallow subtidal zone where lobster larvae recruit from the water column and transition into benthic juveniles. High morality across even in one recruitment class (i.e., year) of spiny lobster can cause substantial declines in lobster populations and catch years after an accident. This has been observed consistently for spiny lobster populations.[60] I also expect lobsters to avoid areas that contain remnant oil, which would be locations in relatively shallow water. This would act to displace spiny lobsters and subsequent catches to deeper offshore areas, where fishing success is usually lower than in shallow water. A similar situation, specifically the influence of oil exposure of juveniles in oil-contaminated benthic habitats and subsequent reduced recruitment, is likely to arise for Dungeness crab and sea cucumbers in the region of the Refugio Oil Spill.

37. Exposure of embryonic and larval fish to even very low concentrations of PAHs can lead to declines in population abundance and subsequent declines in catches for many years after an oil spill. Such is a main lesson of EVOS.[61] The wide dispersion of oil from the Refugio Oil spill undoubtedly exposed many millions of larval fish to lethal and sublethal levels of PAHs throughout the southern California region. And as

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[60] William G. Lyons, *Problems and perspectives regarding recruitment of spiny lobsters, Panulirus argus, to the South Florida Fishery*, 43 Ca. J. Fish. Aquat. Sci. 2099 (1986).

[61] C.H. Peterson et al., *supra* note 1.

explained above[62], the development of coastal eddies has the clear potential to concentrate both fish larvae and oil, thereby enhancing the exposure of sensitive life stages of fish to deformity-causing toxins. The combination of ubiquitous spring spawning, oil in the water, and coastal eddy formation provides a mechanism that I expect will lead to declines in fish abundance and catch of some species, including groundfish like sablefish and thornyheads, over the next decade.

38. A primary cause of cascades of ecological impacts through marine food webs is the reduction of primary production, specifically reduction in the growth of phytoplankton, which normally supplies food for zooplankton, which in turn is eaten by planktivorous larval, juvenile and adult fish, as well as large invertebrate nekton, including squid. These trophic cascades have led to the reduction of fisheries catch and even marine mammal abundance worldwide. Similar trophic cascades are caused by oil spills that reduce primary production, be it by phytoplankton or microbial organisms, with the result being the eventual loss of species caught in fisheries.[63]

39. Oil from the Refugio oil spill caused lower population growth rates in marine coastal phytoplankton species as quantified in well-controlled laboratory mesocosm experiments conducted by Ladd et al. (2018) at UC Santa Barbara.[64] This ecological effect of oil explains several patterns in reduced fish catch observed in fishing blocks targeted by fleets from the Santa Barbara Harbor and other nearby ports. Oil dispersed in surface waters without doubt killed and reduced the abundance of phytoplankton, as per the results of work of Ladd et al. In turn, the reduction of food for zooplankton likely led to the reduction in the abundance of squid and pelagic-neritic fish species. The cascade of ecological linkages caused by the Refugio Oil Spill not only reduced the catches of short-lived species, as confirmed by Dr. Rupert's analyses, but

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[62] Nishimoto and Washburn, *supra* note 54.

[63] Edward J. Buskey et al., *Impact of oil spills on marine life in the gulf of Mexico: effects on plankton, nekton, and deep-sea benthos*, 29 Oceanography 174 (216); J.B.C. Jackson et al., *Ecological effects of a major oil spill on Panamanian coastal marine communities*. 243 Science 37 (1989).

[64] Ladd et al., *supra* note 19.

will over the next several years reduce catches of long-lived benthic species, such as red sea urchins and some groundfishes, specifically through the impact of PAHs exposure to embryos and larvae occurring during the spring and early summer months of 2015.

40. The Refugio Oil Spill leaked a large amount of oil into the marine environment that caused substantial short-term and long-term harm to marine species, many of which are caught in the fisheries operating in the Santa Barbara Channel and adjoining southern California region. Oil was found in high concentrations as far south as Huntington Beach, and in dispersion models as far west offshore as the northern and southern Channel Islands, thereby exposing a very large area to toxic levels of PAHs. The negative short-term acute impacts to fish and invertebrate species of exposure to even very low concentrations of PAHs (e.g., 50 ppb in seawater) is well documented in the scientific literature.[65] Lessons learned from the EVOS and Deepwater Horizon (DWH) Oil spills also shows that exposure to low levels of PAHs, which cause injury to larval and juvenile fish, can lead to subsequent declines in fishery landings.[66]

41. Based on research associated with EVOS, DWH, and many other oil spills, and my own observations of the impact of the Refugio Oil spill, I conclude that the Refugio Oil Spill had severe short-term acute negative impacts on marine species inhabiting the coastal beaches, offshore sandflats, rocky reefs, and coastal pelagic environment of southern California. I also conclude that the exposure of fish and invertebrate embryos, larvae, and juvenile life stages caused substantial mortality, either through acute toxicity or severe developmental abnormalities, thereby reducing the abundance of many species, many of which are critical to fishing communities in the Santa Barbara Harbor and surrounding fishing ports. The negative impacts to early life stages of some species, and potential continued leakage of oil-laden benthic habitats will

[65] G.N. Cherr et al., *Impacts of Petroleum-derived pollutants on fish development*. 5 Ann. Rev. Anim, Biosci. 185 (2017).

[66] Incardona et al. *supra* note 14.

also cause long-term negative impacts on catches and fisheries for many species. This opinion is well supported by the scientific community that acknowledges the severe and long-lasting harm that oil spills have on the marine environment.

I certify that the foregoing is true and correct.

Executed on July 14th, 2019 at Mo'orea, French Polynesia.

Hunter Lenihan

EXHIBIT A

HUNTER STANTON LENIHAN
Curriculum Vitae

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PROFESSIONAL PREPARATION
B.S.: University of California, Berkeley, 1986; Conservation and Resources Studies
M.S.: Moss Landing Marine Laboratories, CA, 1994; Marine Science
Ph.D.: The University of North Carolina at Chapel Hill, 1996; Marine Science
Post-doc: National Research Council Postdoctoral Associateship, NOAA-National Marine Fisheries Service, Beaufort, NC, 1997-1998; Fisheries Ecology
Post-doc: The University of North Carolina at Chapel Hill, Institute of Marine Sciences, Morehead City, NC, 1998-2000; Ecotoxicology
Post-doc: University of California, Santa Barbara, CA, 2001-2002; Coral Reef Ecology

APPOINTMENTS
Fisheries Biologist, NOAA-National Marine Fisheries Service, Groundfish Management Program, Northwest Fisheries Science Center, Newport, OR, 2000-2001
Assistant Professor, University of California, Santa Barbara, 2002-2006
Associate Professor, University of California, Santa Barbara, 2006-2010
Professor, University of California, Santa Barbara, 2010-Present
Director, Sustainable Aquaculture Research Center, University of California, Santa Barbara. See http://SARC.Bren.ucsb.edu. 2015-present
Marine Subject Editor, *Ecosphere*, Ecological Society of America. 2016-present
Board of Directors (Founding Member), Honda Marine Science Foundation, American Honda Motor Corporation. 2016-present
Review Panelist, U.S. National Academy of Sciences, National Research Council, Post-Doctoral Research Associateship Program, 2016-present
McNair Scholars Program, Mentor, University of California, Santa Barbara. 2017-present

GRANTS- PAST 5 YRS
Sarah Argyropoulos Coral Reef Conservation Fellowship. $370,000. 2016-2023.
Oceans Five, Ocean Halo and nearshore fisheries management, $50,000. 2018.
Kabcinell Foundation, Ocean Halo, $300,000. 2017-2020.
Food from the Sea, University of California, Office of the President. $336,000. 2015-2018.
The Nature Conservancy, Data-poor, community-based approaches to managing the CA rock crab fishery. $40,000. 2016-2018.
Santa Barbara Foundation, Developing sustainable aquaculture for under-served communities in Santa Barbara County. $20,000. 2016-2017.
American Honda Motor Co., Inc. Establishing feasibility metrics and generating spatial management plans for native California oyster restoration in southern CA and Baja, Mexico. $37,000. 2016-2017.
American Honda Motor Co., Inc. Crowdsourcing oceanographic data with Honda-powered marine sensors: A Bren-Honda partnership for detecting global ocean change $30,083. 2016-2017.
CA Sea Grant, Impacts of neonicotinoid pesticides on estuaries and coastal Streams,

$304,000. 2016-2018.

CA Sea Grant. Developing ecosystem-based approaches to high seas thresher shark fishery management. $96,240. 2014-2017.

Center for the Environmental Implications of Nanotechnology. National Science Foundation, Science and Engineering Center. $48 million. 2008-2018.

Moorea Coral Reef LTER. National Science Foundation, LTER Program. $3.9 million. 2013-2019.

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Couture, J., R. Geyer, J. Øvrum Hansen, B. Kuczenski, M. Øverland, J. Palazzo, C. Sahlmann, and H.S. Lenihan. 2019. Environmental benefits of novel non-human food inputs to salmon feeds. **Environmental Science and Technology**. In press.

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RESEARCH CENTER

Founder and Director, Sustainable Aquaculture Research Center, University of California, Santa Barbara. 2015-present

FELLOWSHIPS AND HONORS

Distinguished Teaching Award, Bren School of Environmental Science and Management, U.C Santa Barbara, 2016
California Governor's Environment and Economic Leadership Award in Green Chemistry (awarded to the U.C. Center for Environmental Implications of Nanomaterials (UC CEIN), 2012
Association of Pacific Rim Universities Fellow, UCSB, 2004
US National Research Council Post-doctoral Associate, 1996-1997
ARCS Foundation Achievement Award for College Scientist, 1991
Dr. Earl and Ethel Meyers Oceanography and Marine Biology Trust Scholarship, 1990

PROFESSIONAL MEMBERSHIPS

Ecological Society of America
International Coral Reef Society
Western Society of Naturalists

TEACHING EXPERIENCE

Bren School, Masters of Environmental Science and Management, Specialization Leader for Coastal Marine Resource Management, 2002-present
Bren School Faculty Adviser for Latin American Fisheries fellowship, 2011-present
Scientific writing, University of California, Santa Barbara, 2016-present
Equity in Environmental Science and Management, 2019.
Aquaculture and ecosystems**,** University of California, Santa Barbara, 2011-14
Fisheries Management, University of California, Santa Barbara, 2007-2013
Applied Marine Ecology, University of California, Santa Barbara, 2001-present
Coastal Marine Ecosystem Processes, University of California, Santa Barbara, 2005-present
Restoration Ecology, University of California, Santa Barbara, 2004-2008
Ecological Impacts of War, University of California, Santa Barbara, 2004
Ecology of Marine Reserves, University of Washington, Friday Harbor Laboratories, 2003
Coastal Marine Toxicology, UC Davis, Bodega Bay Laboratories, 2003-2004
Lectured in Conservation Planning, Ecology, etc., University of California, Santa Barbara, 2003-present
Ocean Ecology, University of North Carolina at Chapel Hill, Institute of Marine Sciences, 2000

PHD STUDENTS GRADUATED (*2006-2017*)

Heather Coleman, *Ecotoxicology*
Debra McArdle, *Marine conservation*
Matthew Kay, *Fishery ecology and management*
Carla Guenther, *Socio-ecological system science*
Jono Wilson, *Fishery management*
Annie Yau, *Fishery management*
Tal Ben-Horin, *Disease ecology*
Shannon Hanna, *Ecotoxicology*
Sarah Valencia, *Fishery management*

PHD STUDENTS PRESENT (*2014-PRESENT*)

Caroline Vignardi, *Ecotoxicology*
Sean Fitzgerald, *Fishery management*
Jose Zenteno, *Aquaculture*
Erin Winslow, *Marine conservation*

SCIENTIFIC REVIEWING

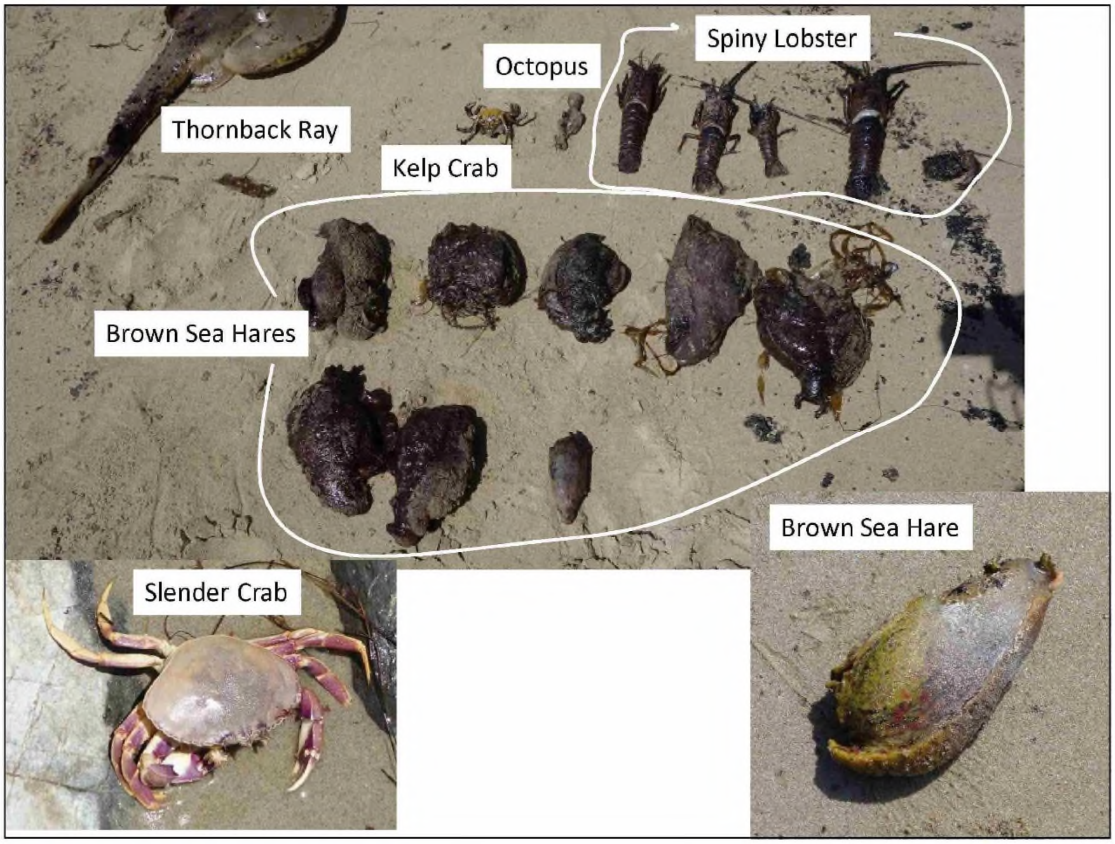
Marine Subject Editor, *Ecosphere*, 2016-present
NSF-LTER Site Selection Panel, 2016.
Biological Oceanography Panel, National Science Foundation, 2008, 2012, 2015, 2016
CAMEO Panel, NOAA-NSF, 2011
NSF Biological Oceanography Proposal Reviewer
NSF Environment, Society, and Economics Reviewer
NSF Physical Oceanographer Reviewer
NSF Sediment geology and Paleobiology Reviewer
NSF Office of Polar Programs Reviewer
NSF Coupled Natural-Human Systems Reviewer
Australian Research Council Proposal Reviewer
CA Ocean Protection Council Reviewer
Sea Grant Program Reviewer for CA, USC, MD, AK, MA, VA, FL, and NC
Reviews for multiple scientific journals: ASC Nano, Biology Letters, Bulletin of Marine Sciences, Bulletin of the CA Academy of Sciences, Canadian Journal of Fisheries and Aquatic Sciences, Coral Reefs, Fisheries Research, Ecological Applications, Ecology, Ecology Letters, EcoSphere, ESA Frontiers, Environmental Science and Technology, Estuarine Coastal and Shelf Sciences, Fisheries Bulletin, Fisheries Research, Journal of Experimental Marine Biology and Ecology, Journal of Hazardous Materials, Limnology and Oceanography, Marine Biology, Marine Ecology Progress Series, Marine Environmental Research, Nanotechnology, Nature, Oecologia, PlosOne, Proceedings of the National Academy of Sciences, Science, Theoretical Population Biology.

SELECTED INVITED PRESENTATIONS

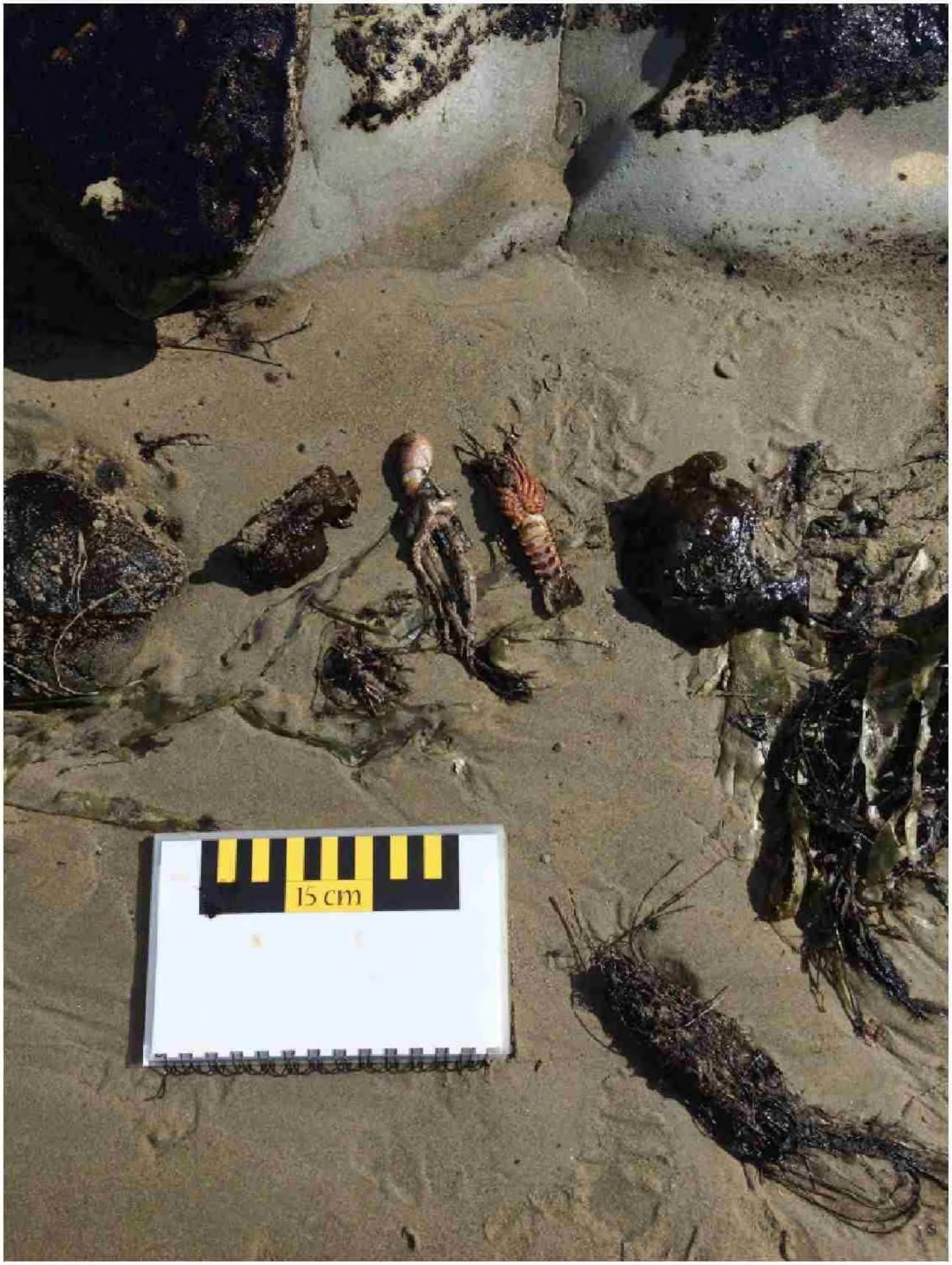
Department of Marine Resources, Fisheries Management, French Polynesia, 2019
University of California, Berkeley, Gump Biological Station, Moorea, 2018
Department of the Environment, French Polynesia, 2018
University of North Carolina, Institute of Marine Sciences, 2018
NOAA-Habitat Restoration Program, Beaufort, NC, 2018
Department of Marine Resources, Fisheries Management, French Polynesia, 2018
Duke University Marine Laboratory, Beaufort, NC, 2017
University of Zurich, Department of Evolutionary Biology and Environmental Sciences, 2017
Duke University, Nanoscience Conference, 2016
UC Nanomaterial Exposure Workshop, UCLA, 2015
Food from the Sea Summit, UC Santa Barbara, 2015
UC Davis, Bodega Marine Laboratory Seminar Series, 2014
Sustainability of Nanotechnology Organization, UC Santa Barbara, 2013
Department of Economics, Universidad de Concepcion, Chile, 2013
Department of Economics, Universidad de Talca, Chile, 2013
International Coral Reef Symposium, Cairns, Australia, 2012
NSF Nanoscale Science and Engineering Grantees Conference: Focus on Environment, Wash., DC, 2012
Duke University Marine Laboratory, Beaufort, NC, 2011
Department of Geography, UC Santa Barbara, 2011
CA World Oceans, San Francisco, CA, 2010
Channel Islands National Park, Ventura, CA, 2010
Channel Islands National Marine Sanctuary, Santa Barbara, CA, 2010
Engineering Department, UCLA, 2010
Institute of Marine Sciences, UNC, Chapel Hill, NC 2010
NSF Mini-Symposium on Social-Ecological Science within the LTER Program, Washington, DC, 2010
CA Depart. of Fish and Game Commission, Marine Resources Subcommittee, Santa Barbara, CA, 2009
Marine Science Institute, UC Santa Barbara, CA, 2008

Bodega Marine Laboratory, UC Davis, CA, 2007
California World Oceans Conference, Long Beach, CA. 2006
West Coast Native Oyster Restoration Conference, San Francisco, CA, 2006
CEA-CREST, Cal State University- Los Angeles, CA, 2006
Environmental Fluids Mechanics Laboratory, Stanford University, 2006
Ecology and Evolutionary Biology, University of California, Santa Cruz, 2005
UCSB Bren School Dean’s Council Breakfast Club, University Club, Santa Barbara, CA, 2004
Bernumwood Seminar Series, Montecito, CA, 2003
UCSB Bren School Dean’s Council Meeting, University of California, Santa Barbara, CA, 2003
Coral Reef Fish Conservation Conference, Moorea, French Polynesia, 2002
Netherlands Journal of Sea Research 125 yr. Anniversary, Amsterdam, 2001
Scientific Committee on Antarctic Research, Amsterdam, 2001
Biological Sciences, University of New Hampshire, Departmental Seminar, 2001
School of Biology, Department, Georgia Tech University, Departmental Seminar, 2001
Ancona Marine Laboratory. Departmental Seminar, Ancona, Italy, 1999
International Shellfish Restoration Conference, Cork, Ireland, 1999
British Ecological Society, Sussex, England, 1999
National Science Foundation, McMurdo Station Seminar Series, Antarctica, 1998
Earth and Atmospheric Sciences, University of California, Santa Cruz, CA. Departmental Seminar, 1998
Curriculum in Marine Sciences, University of North Carolina at Chapel Hill, NC. Depart. Seminar, 1997
Ecology, Evolution, and Marine Biology, UCSB, Depart. Seminar, 1997
International Shellfish Restoration Conference, Hilton Head Island, S.C., 1995 and 1998
North Carolina Marine Fisheries Commission, Raleigh, N.C., 1993
International Marina Conference, Kingston, R.I., 1989

EXHIBIT B



OSPRKellerR-00003181



OSPRKellerR-00011143

OSPRKellerR-00016219

OSPRKellerR-00016521

EXHIBIT C

Map of Toxic Blocks

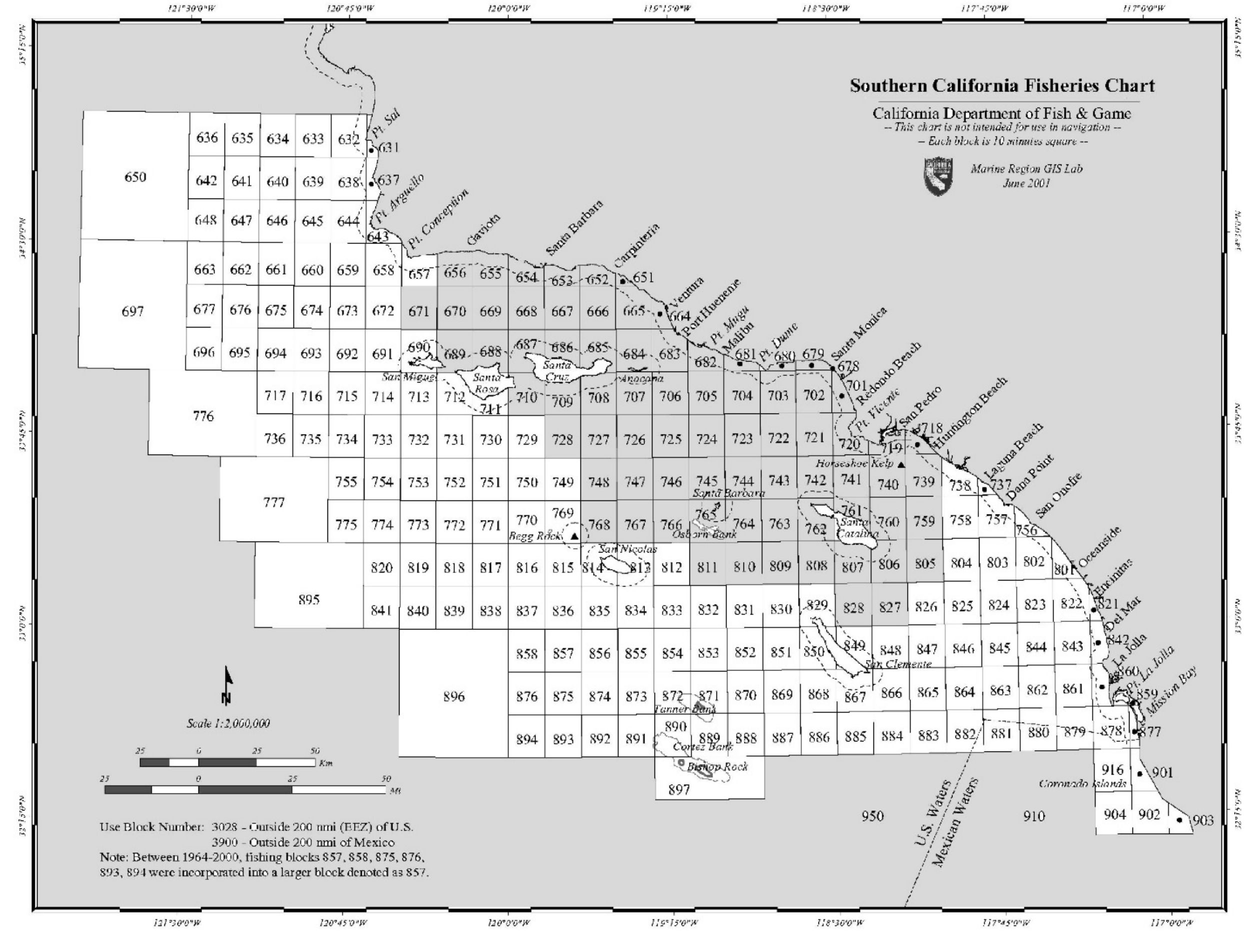


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EXHIBIT E

MATERIALS CONSIDERED BY HUNTER LENIHAN

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